



X5MBTCP01 MODBUS TCP OPTION BOARD WITH 115 VAC ENCODER INTERFACE

INSTALLATION MANUAL

DPD00112

INSTALLING THE X5MBTCP01 MODBUS TCP OPTION BOARD WITH 115 VAC ENCODER INTERFACE

INTRODUCTION

The X5 frequency converters can be connected to Modbus TCP using a Modbus TCP option board, the X5MBTCP01.

Every device connected to a Modbus / TCP network has two identifiers: a MAC address and an IP address. The MAC address (formatted as xx:xx:xx:xx:xx:xx, where xx is a hexadecimal byte) is unique to the device and cannot be changed. The Modbus / TCP board's MAC address can be found on the sticker attached to the board or by using various network configuration tools.

In a local network, IP addresses can be defined by a user as long as all units connected to the network are given the same network portion of the address. For more information about IP addresses, contact your Network Administrator. Overlapping IP addresses cause conflicts between devices.

The X5MBTCP01 also provides the option of controlling the X5 AC drive from 115 VAC control signals, or of connecting a shaft-mounted encoder to the drive to improve speed regulation. Up to five channels of 115 VAC control are available for use in selecting direction, preset speeds, or other drive functions.

With this option, an encoder with a nominal rating of up to 2048 pulses per revolution can be connected to the X5 unit to improve speed load regulation of the drive. Overall encoder frequency at maximum process speed must be limited to 100kHz.

This option also provides two additional control relays, each rated for 115 VAC, 1 amp, or for 230 VAC, 0.5 amp.

NOTE: This network communication interface included with the X5 option is warranted to meet the core specifications for Modbus TCP. Many existing software applications are custom-engineered and may contain "brand-specific" communication that will not be supported by the X5 without modification. No guarantee of compatibility with any specific system is made. The user is responsible for any interface software and hardware needed to make an application function.

APPLICABLE DOCUMENTS

This manual is supplied as a supplement to the X5 AC Drive User's Manual (DPD 00089, previously Form 1434).

OPTION KIT CONTENTS

The option kit includes the following materials:

Part Number	Description
25100104C	Modbus / TCP Option Board
32100391	Flexible cable assembly

INSTALLATION PROCEDURES

WARNING

SENSITIVE EQUIPMENT

This assembly contains static-sensitive components. It should be handled only by a static-safe installer, using a grounded wrist strap.

Failure to observe this precaution may cause premature equipment failure.

⚠ DANGER

HAZARDOUS VOLTAGE

- Disconnect all power before servicing a drive unit or its components. **WAIT 5 MINUTES** until the DC bus capacitors discharge.
- Ensure that any other power sources that may feed control logic have been disconnected.
- **DO NOT** short across DC bus capacitors or touch unshielded components or terminal strip screw connections with voltage present.
- Install all covers before applying power or starting and stopping the drive.
- The user is responsible for conforming to all applicable code requirements with respect to grounding all equipment.
- Many parts in a drive, including printed circuit boards, operate at line voltage. **DO NOT TOUCH.** Use only electrically-insulated tools.

Before servicing any drive.

- Disconnect all power.
- Place a "DO NOT TURN ON" label on the drive disconnect.
- Lock the disconnect in the open position.

Failure to observe these precautions will cause shock or burn, resulting in severe personal injury or death.

Figure 1 shows the option board and the location of the terminals and the power supply selector.

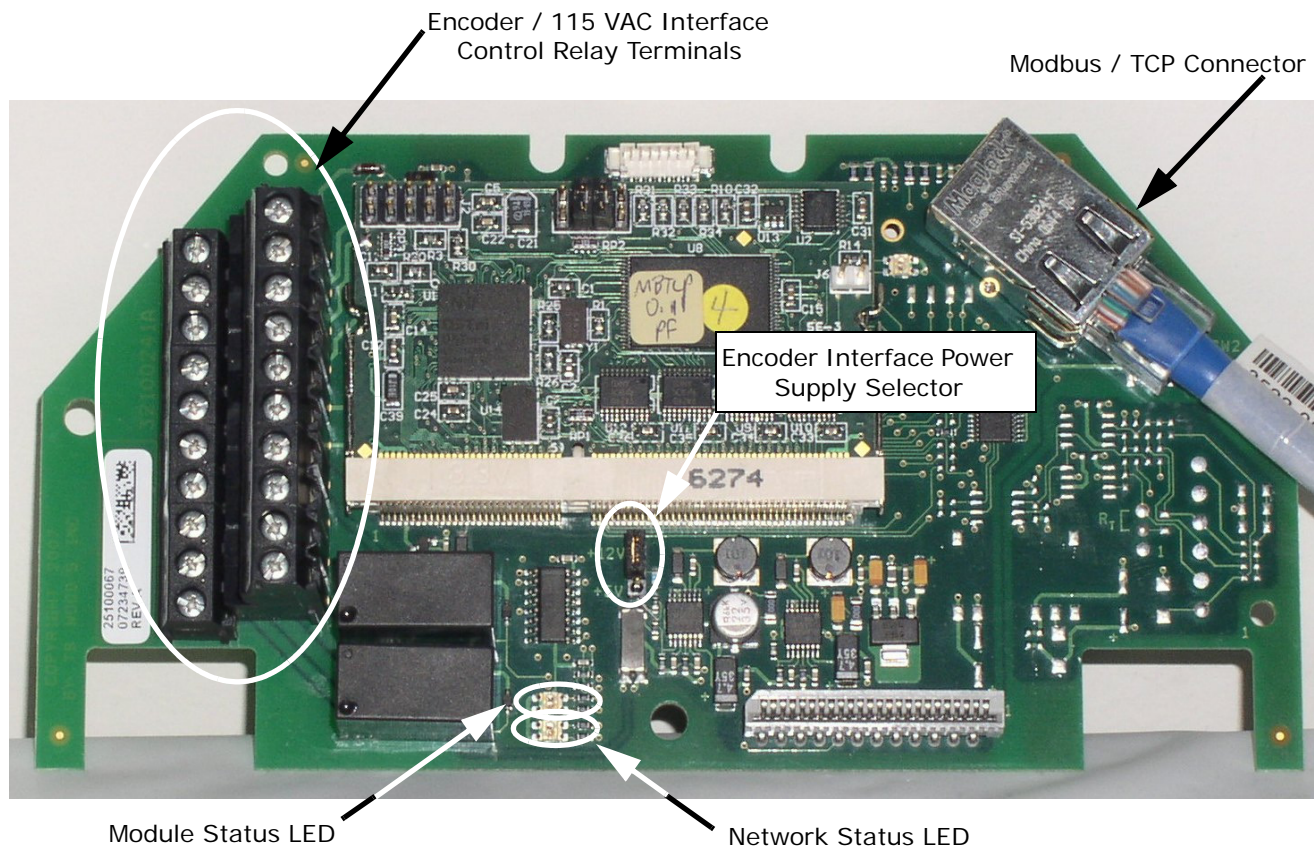


Figure 1: Option Board Layout

Before you can install the option board, you must first remove the drive cover.

Figure 2 shows the locations of the cover screws. The torque range for the X5 Size 1 cover is 18-26 in/lbs.



Figure 2: Cover Assembly and Screw Locations

The option board is installed just above the control board in all configurations (a Size 1 unit is shown in Figure 3 for reference). The screws labeled "A" must be removed from the X5; those labeled "B" need only to be loosened to accept the board slot.

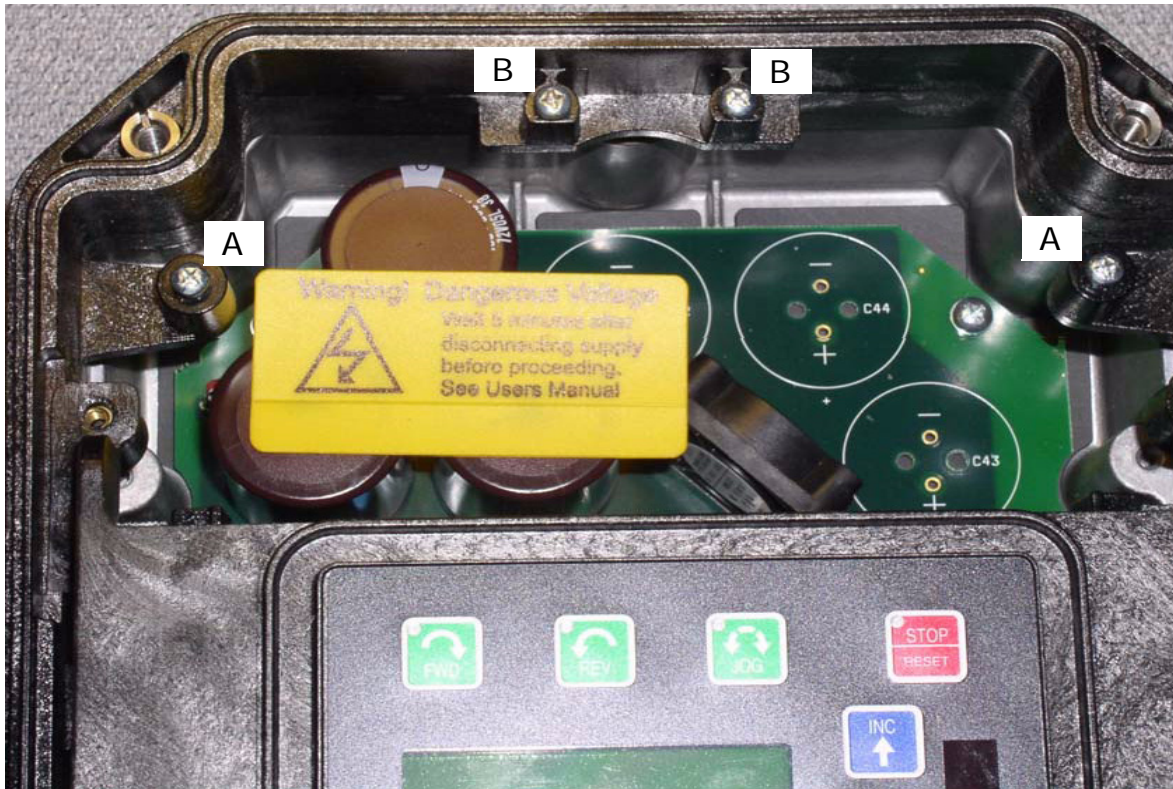


Figure 3: Option Mounting Locations

Once the board is in place, tighten the screws to a maximum of 26 in-lbs.

Next, install the flexible circuit to finish the interface to the control board. (Refer to Figure 4.) To install the flexible circuit, first remove the keypad frame (necessary in this size unit). The frame is attached with two screws in opposite corners; the screws thread into fasteners in the plastic assembly. After the flexible circuit is installed, replace these screws, limiting the installation torque to 12 in-lbs..

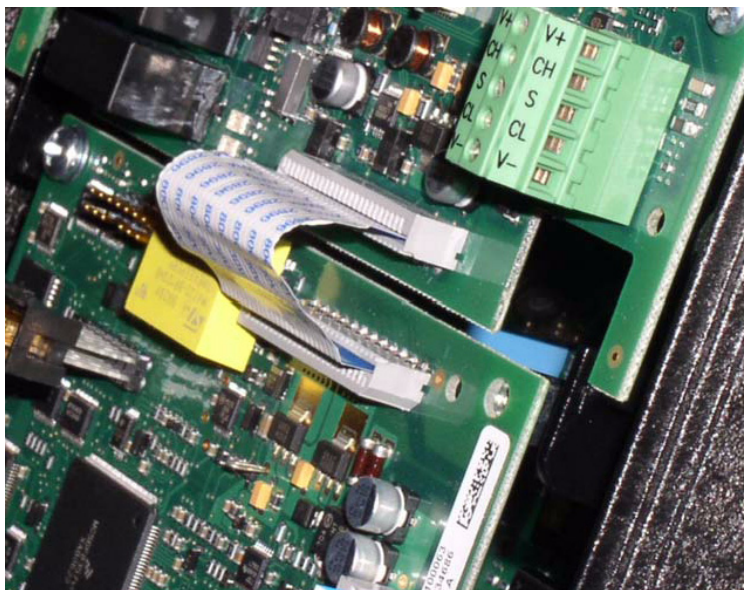


Figure 4: Flexible Circuit Interface to Control Board

115 VAC INTERFACE / RELAY / ENCODER INTERFACE TERMINALS



Figure 5: 115 VAC Interface / Encoder Terminals

The X5OPT01 option kit includes five 115 VAC inputs, two additional programmable relays, and an encoder interface. The details of the terminals on the board related to the 115 VAC interface and the encoder are shown in Table 1 on page 7:

Table 1: Encoder Interface Terminals

Terminal	Description
DI-A DI-B DI-C DI-D DI-E	115 VAC logic input; connect input to 115 VAC to activate. The programmable functionality of these inputs is controlled by parameters 728, 729, 730, 731, and 732. Each of these inputs can be disabled or configured to emulate the function of the FWD, REV, R/J, EN, M0L, DI1, DI2, DI3, DI4, or DI5 input terminals on the X5 control board. Refer to the X5 User's Manual for more information (DPD 00089).
ACn	The neutral connection for the 115 VAC control inputs
N03 RC3 NC3	The third auxiliary relay. The function of this relay is set by parameter 709. Functionally, it is capable of each of the features outlined in the X5 user manual under parameters 705-708. Terminal N03 is a normally-open contact; it closes when the relay activates. NC3 is a normally-closed contact; it opens when the relay activates. RC3 is the common terminal associated with both contacts. The ratings of these contacts are 115 VAC, 1 amp; and 230 VAC, 0.5 amp.
N04 RC4 NC4	The fourth auxiliary relay. The function of this relay is set by parameter 710. Functionally, it is capable of each of the features outlined in the X5 user manual under parameters 705-708. Terminal N04 is a normally-open contact; it closes when the relay activates. NC4 is a normally-closed contact; it opens when the relay activates. RC4 is the common terminal associated with both contacts. The ratings of these contacts are 115 VAC, 1 amp; and 230 VAC, 0.5 amp.
A+ A-	Channel A input from the encoder. Compatible with line driver, open collector, or totem pole outputs from an encoder. If it is an open collector or totem pole-type, encoder outputs are used; connect the A-terminal to Ecom.
B+ B-	Channel B input from the encoder. Compatible with line driver, open collector, or totem pole outputs from an encoder. If it is an open collector or totem pole-type, encoder outputs are used; connect the B-terminal to Ecom.
C+ C-	Channel C input from the encoder, the home pulse. Compatible with line driver, open collector, or totem pole outputs from an encoder. If it is an open collector or totem pole-type, encoder outputs are used; connect the C- terminal to Ecom.
VDC	Power supply terminal for use with a customer-supplied encoder. It can be either +12 VDC or +5 VDC based on the position of the encoder interface power supply selector shown in Figure 1. Voltage regulation: +/- 5%; maximum current available is 100 mA.
Ecom	Signal common for the encoder interface

Note that the connections described in [Table 1](#) work only when the encoder has an internal pull-up resistor on the open collector. Alternatively, it might be preferable to pull the + channel high, and attach the open collector to the - channel. For example, if using Channel A, A+ on the option board would be tied to VDC, and A- would be connected to the open collector coming from the encoder. The advantage in this method is that no pull-up/down resistors are needed; if the encoder has an internal pull-up, this does not affect anything.

SPECIFICATIONS FOR ENCODER / 115 VAC INTERFACE

Encoder Interface		115 VAC Interface	
Speed regulation	< 0.1 Hz [1]	On state	90-140 VAC
Input frequency (max.)	100 kHz	Off state	< 10 VAC
Input voltage	10-24 VDC +/- 5%	Input frequency	58-62 Hz
Suggested pull-up resistor	5 VDC	On/off delay	30 ms maximum
	12 VDC		
	24 VDC		
Terminal block wire limitations	12-24 AWG	Terminal block wire limitations	12-24 AWG
[1] PID feedback plus optimal motor turning in SLV mode employed			

SETUP AND USE

The encoder interface is most effective if used in conjunction with the vector mode of operation. Refer to the X5 User's Manual (Chapter 6) for information about using the vector mode. Three additional parameters are provided to calibrate the encoder:

Parameter #	Parameter Name	Range	Default Value
219	Encoder Pulses per Revolution	0-16383	1024
220	Encoder Filter Time	10-1000 ms	20 ms
221	Encoder Speed Protection	0-20.0%	0%

Parameter 219, Encoder Pulses per Revolution, can either be extracted from the encoder nameplate or the data sheet supplied with it. Parameter 220, Encoder Filter Time, is used to filter the encoder signal in the event of noise. Parameter 221 is for limiting the response of the drive, in the event of the loss of encoder signal.

Two other parameters are provided to allow more flexibility in encoder selection, and to improve PID application usage:

Parameter #	Parameter Name	Range	Default Value
223	EncoderType	Quadrature or Single Channel	Quadrature
224	Encoder Range	0-24000 rpm	0 rpm

Parameter 223, Encoder Type, allows the use of either quadrature or single-channel types of encoders.

Parameter 224, Encoder Range, improves PID application flexibility. This parameter should be used in situations where the encoder feedback signal is not always directly proportional to the motor speed, for example, a winder using an encoder mounted on an idler pulley feeding a winding spool. The PID may be attempting to maintain a constant linear speed on the wound media, but as the diameter of the media on the spool changes, the motor turning the spool needs to vary its speed to maintain the linear speed at the idler pulley.

When parameter 224 is set to 0, it is ignored, and the PID calculates the feedback percentage based on parameter 301, Maximum Frequency. When this parameter is set to a non-zero value, the PID uses instead Parameter 224's setting to calculate the feedback percentage.

Encoder feedback works similarly to an analog input as configured in parameters 850 (PID Configure), 851 (PID Feedback), 852 (PID Prop Gain), 853 (PID Int Gain), and 859 (PID Derivative Gain). The "feed forward" options are suggested for setting parameter 850. More specific details on each of the listed parameters can be found in the X5 User's Manual (DPD 00089).

The encoder interface can easily serve as one of the inputs to the X5's Keeper Function (data logging). See the X5 User's Manual for more information.

Both the Vmet and Imet output from the drive can be configured to indicate the status of the encoder. Parameters 700 (Vmet) and 702 (Imet) that relate to the setup and calibration of the Vmet and Imet outputs, both have selections related to the status of the encoder input.

The Program Sequencer function can also key off the encoder's home pulse. To make use of this function, the encoder's home pulse (1 pulse per revolution) must be connected to the C- input of the encoder board.

TROUBLESHOOTING

Any problem with the encoder interface will result in an F37 fault. Four advanced fault codes are available to help you determine whether you have an encoder calibration problem, or a defect. For more information on troubleshooting, refer to the Troubleshooting chapter in the X5 User's Manual.

USING MODBUS / TCP

Following are the specifications for Modbus / TCP connections:

Table 2: Modbus / TCP Connection Specifications

Connections	Interface	RJ-45 Connector
Communications	Transfer cable	Foiled CAT5e
	Speed	10 / 100 Mb
	Duplex	half/full
	Default IP address	0.0.0.0
	Sub-net mask	255.255.255.0

To communicate with the drive over Modbus / TCP, the drive's IP address must be set. This is done with parameters 922-925. After setting the IP address, be sure to cycle power off and back on for the new address to take effect.

LED Indications

The Modbus / TCP Option Board includes two LED status indicators: Network Status and Module Status. See [Figure 1 on page 4](#) for the location of these LEDs on the board. Network status provides information on the network connection status and Module status provides information on the Modbus / TCP module itself. The following tables explain the meaning of the status LEDs:

Table 3: Network Status LED

Network Status LED	If the LED is...	This means...
	OFF	There is no power applied to the option board.
	Red	The Modbus / TCP option cannot communicate on the network.

Table 4: Module Status LED

Module Status LED	If the LED is...	This means...
	OFF	There is no power applied to the option board.
	Green	The option board is operating normally.
	Green (flashing)	The option board is in Standby state or the device needs commissioning because of a missing, incomplete, or incorrect configuration.
	Red (flashing)	The option board has detected a recoverable fault.
	Red	The option board has detected an unrecoverable fault.

Getting Started

To begin communicating with the drive over Modbus / TCP, the drive's IP address must be set (use parameters 922-925). After setting the IP address, cycle power off and on for the new address to take effect.

For information on setting parameters, see the X5 User's Manual.

Modbus / TCP is a variant of the Modbus family. It is a manufacturer-independent protocol for monitoring and controlling automatic devices. Modbus / TCP is a client server protocol. The client makes queries to the server by sending request messages to the server's TCP port 502. The server answers client queries with a response message. The term "client" can refer to a master device that runs queries. Correspondingly, the term "server" refers to a slave device that serves the master device by answering its queries. Both the request and the response messages are composed as follows:

Byte	Content
0	Transaction ID
1	Transaction ID
2	Protocol ID
3	Protocol ID
4	Length field upper byte
5	Length field upper byte
6	Unit identifier
7	Modbus function code
8	Data (of variable length)

Modbus / TCP vs. Modbus / RTU

Compared to the Modbus / RTU protocol, Modbus / TCP differs mostly in error checking and slave addresses. As TCP already includes an efficient error-checking function, the Modbus / TCP protocol does not include a separate CRC field. In addition to error checking functionality, TCP is responsible for re-sending packets and for splitting long messages so that they fit the TCP frames. The slave address field of the Modbus / RTU is named as the unit identifier field in Modbus / TCP, and it is only used when one IP address stands for several endpoints.

Modbus / TCP Option Board's Modbus Addresses

Currently, the X5 only implements Modbus holding registers (addresses 40001 - 4FFFF). The Modbus / TCP option board supports the same register ranges and function codes that are available through the drive's serial port via Modbus RTU. For more information, see Chapter 7 of the X5 User's Manual.

MODBUS / TCP TROUBLESHOOTING

Following are the advanced fault codes for the drive fault (F38) related to the option board. For more information, see the X5 User's Manual (Chapter 8). The [option board status LEDs](#) are described on [page 9](#) of this manual.

Table 5: Advanced Fault Codes

Advanced Fault Code	Fault	Possible Cause	Corrective Measures
1	Option board loss	Option board is disconnected or damaged	Check option board status LEDs, ribbon cable connection, and cycle power. Replace option board if necessary.
2	Unstable ID during power-up	Option board hardware issues	Cycle power. If problem persists, contact Vacon technical support.
3	Option board changed	Option board was changed during last power-down	If the change was intentional, cycle power.
4	Invalid ID	Option board hardware issues	Cycle power. If problem persists, contact Vacon technical support.
5	Wrong or no daughter card installed	Option DIMM module issues	Cycle power. If problem persists, contact Vacon technical support.
6	Option board software	Option board software issues	Cycle power. If problem persists, contact Vacon technical support.
7	Option board removed	Option board was removed during last power-down sequence	If the change was intentional, cycle power. Otherwise, follow corrective measures for fault code 1.

Following are Modbus / TCP Exception Responses:

Table 6: Exception Responses

Error Response	Name	Meaning
1	Illegal Function	The function code received in the query is not an allowable action for the slave. For example, this error would be returned when attempting to write (preset) a read-only register.
2	Illegal Data Address	The data address received in the query is not a valid address in the slave.
3	Illegal Data Value	A value contained in the query data field is not an allowable value for the slave register (that is, above the parameter's maximum or below the minimum).
4	Slave Device Failure	An unrecoverable error occurred while the slave was attempting to perform the requested action.
5	Acknowledge	The Modbus / TCP option board is having trouble communicating with the X5 control board.
6	Slave Device Busy	The slave cannot process the request at this time. The master should re-transmit the message later when the slave is available. This usually only occurs when two masters simultaneously query a slave, or the polling rate from the master is too fast for the slave.